TOWER CREEK BRIDGE
Yellowstone Roads and Bridges
Spanning Tower Creek on Grand Loop Road
Yellowstone National Park
Park County
Wyoming

HAER No. WY-33

HAER
WYO
15-YELNAP,
20-

BLACK & WHITE PHOTOGRAPHS

WRITTEN HISTORICAL & DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
U.S. Department of the Interior
P.O. Box 37127
Washington, DC 20013-7127

Rocky Mountain Regional Office
National Park Service
U.S. Department of the Interior
P.O. Box 25287
Denver, Colorado 80225

HAER
WYO
15-YELNAP,
20-

HAER WY-33

HISTORIC AMERICAN ENGINEERING RECORD

TOWER CREEK BRIDGE
~~HAER WY-33~~

Location:	Spanning Tower Creek on Grand Loop Road, 2.3 miles south of Tower Junction, Yellowstone National Park, Park County, Wyoming UTM: Tower Junction, WY, Quad. 12/548400/4970960
Date of Construction:	1933
Designer:	Bureau of Public Roads
Builder:	McLaughlin Construction Company, Livingston, Montana
Owner:	Yellowstone National Park, National Park Service
Use:	Vehicular bridge
Significance:	Tower Creek Bridge typifies the early design philosophy of the National Park Service, which was to use indigenous materials to harmonize man-made features with their natural surroundings. This philosophy is embodied in many of the park's Rustic Style buildings and structures.
Project Information:	Documentation of Tower Creek Bridge is part of the Yellowstone Roads and Bridges Recording Project, conducted during the summer of 1989 by the Historic American Engineering Record, a division of the National Park Service, under the co-sponsorship of Yellowstone National Park, the NPS Roads and Bridges Program, and the NPS Rocky Mountain Regional Office, Denver. Historical research and written narrative by Mary Shivers Culpin, Historian, NPS Rocky Mountain Regional Office. Engineering description by Stephen M. Varner, Virginia Polytechnic Institute. Edited and transmitted by Lola Bennett, HAER Historian, 1993.

HISTORY OF GRAND LOOP ROAD: LAKE JUNCTION TO TOWER JUNCTION

The first Superintendent of Yellowstone National Park, Nathanial P. Langford, planned the present circuit system (Grand Loop Road) soon after taking his position in 1872. His idea for a route through this section of the park called for the wagon road to follow the Yellowstone River northward from it outlet to the Yellowstone Falls, past Mount Washburn and on to Tower Falls. Captain William Jones' 1873 survey for a wagon road route from Camp Brown in northwestern Wyoming to Fort Ellis, Montana, recommended that the route follow the Upper Yellowstone River, via Lake Yellowstone, to Tower Junction and on to Gardiner, Montana, through Mammoth Hot Springs.[1] The park received no appropriation for roads until 1878, and by that time, the second superintendent, Philetus Norris, had to use the money for construction of the road from Mammoth Hot Springs. Norris descrbed the difficulties of finding a suitable route through the park:

> From the falls of Tower Creek I explored its canyon and the canyon and valley of Antelope Creek above it, the timbered plateau between them, and also that between the latter and the Grand Canyon. I found the latter very elevated, but open, smooth, and grassy, with a fine lake upon its summit, mainly an excellent route, with magnificent scenery along the yawning, sulphur scented and stained canyon, for some 6 or 8 miles, and past the ruins of an ancient once loopholed, earth-roofed block-house some 16 by 20 feet in diameter and of unknown origin, to a dense forest at the foot of a bald rocky spur of Mount Washburn. ... a careful exploration of the first one from its towering front in nearly a foot of newly fallen snow, through a belt of dense pine, fir, and cedars to near the main mountain, resulted in there finding a pass excellent for a bridle-path, and practicable for a wagon-road, at a much lower altitude than the old route. ... I there, in the gathering twilight, thankfully enjoyed the greeting shout and blazing camp-fire of my men, just safely arrived with the welcome intelligence that they had found a route in all respects preferable to that over the mountain to Cascade Creek. ... As before stated, portions of any possible route upon either side of the Grand Canyon between the forks and the falls of the Yellowstone will be elevated and expensive especially for a wagon road. That upon the eastern side of the canyon is utterly impracticable that within it, unknown but doubtless mainly so, while the two remaining that I explored is the shortest, least elevated, and the easiest of construction, in fact, in all respects so preferable that I have no question of its adoption of all purposes other than a lofty, bridle-path lookout, for which purpose a portion of the old route, a branch from the new one over Mount Washburn or both will be ever desirable. Not only was the route thus found less rugged and difficult than feared, but also the Grand Canyon was shorter and especially its lower portion less deep and yawning than has been considered. Still it is especially from its yellow and crimson geysers to the falls, beautiful and grand beyond conception, a leading wonder of the park, and of the world, every way worthy of a route along or as near as possible to its misty and

sulphur-tinted walls.[2]

The following year (1879), Norris and his crew improved an existing trail from the outlet at Yellowstone Lake to the east canyon of Gardner River, via Mud Volcano, Sulphur Mountain, Great Falls and the Grand Canyon of the Yellowstone, Mount Washburn, Tower Falls, and the Forks of the Yellowstone. The abundance of snow prevented Norris from completing a trail along the rim of the Grand Canyon of the Yellowstone, which he continued to feel was the "true one" for a wagon road or bridle trail to the eastern spurs of Mount Washburn, instead of over it.[3]

In 1880 several bridges were completed in the park, including ones over Tower Creek, Cascade Creek, and other creeks near the Great Falls of the Yellowstone.[4] The following year, two bridges were built over Alum Creek, two bridges over Sage Creek and two bridges over Hot Spring Creek.[5] These bridge projects were part of Norris' overall project of completing the Mammoth Hot Springs to West Entrance route via Tower Falls, Lake Yellowstone, the geyser basins, and the forks of Firehole River. Norris knew that the road between Tower Falls and the mouth of Alum Creek would be costly to build. Together with the abysmal Tower Creek Canyon, the ascent of Mount Washburn via Rowland's Pass, the extensive need of rock-work, culverts, timber-cutting, grading and bridging along the route, Norris calculated that an appropriation of at least an additional $10,000 to supplement the regular appropriation might cover the cost of the road. The use of this amount would not allow for any other construction projects elsewhere in the park.[6]

Finding construction of the section along the bank of the Yellowstone River as costly as Norris predicted, his successor, P.H. Conger, completed a three-mile section of road along the bank of Yellowstone River near the falls and canyon. This provided tourists with safer and more comfortable access to the park's wonders.[7]

Compared to the road work between Mammoth Hot Springs and Madison Junction, very little work was done on this section after the U.S. Army Corps of Engineers assumed responsibility for park road construction and improvement in 1883. By 1885, $25,000 had been spent on construction of a road from the Yellowstone Falls via the east trail over Mount Washburn to Yancy's on Mammoth Hot Springs road. In 1887 the road from the Yellowstone Falls to Lake Yellowstone was described as "not ordinarily in condition for travel before about the middle of July, the altitude being such as to prevent the early melting of the snow.[8]

During 1888 the engineers recommended that fourteen miles of rough road from Lake Yellowstone along the Yellowstone River to the Grand Canyon of the Yellowstone be improved and completed and a new twenty-mile road from the Grand Canyon to Yancy's be built. In the 1889 report to the Secretary of War, Major Allen noted the bridges in the park, including a 115-foot trestle near Yellowstone Falls, and a 40-foot truss bridge with a trestle approach over Cascade Creek.[9]

The road from the Grand Canyon of the Yellowstone to West Thumb via Lake Yellowstone was one of Lt. Hiram Chittenden's first projects after he assumed responsibility for road improvement and construction in the park in 1891. By 1892 the 52-mile road from the Grand Canyon to the Upper Geyser Basin via Lake Yellowstone, which opened during the fall of 1891, was in good condition.[10]

In 1893 work continued on the road that passed near the Upper Falls and a road near the Grand Canyon at Inspiration Point was opened.[11] The next year the crews completed an arch bridge near the Upper Falls, and the following year (1895) a new road was built from the brink of the Grand Canyon to Inspiration Point, via a point over the Lower Falls, and a new road from just south of Alum Creek around Sulphur Mountain, joining the old road near Antelope Creek.[12]

In 1896 Park Superintendent Captain George Anderson engaged the chief engineer of the Northern Pacific Railway to develop plans for an iron bridge across Yellowstone River above the

Upper Falls. Determined that the visitors should be able to view the Grand Canyon from the eastern bank, Anderson decided that if the cost were not excessive, he would have an attractive iron bridge built.[13]

Lt. Chittenden returned to Yellowstone in 1899 to resume responsibility for road construction projects. In his 1899 report, Chittenden described the road along Yellowstone River:

> This length of 15 miles is one of the best-graded roads in the park, carefully laid out by instrumental survey and equal in this respect to any road in the world; but the material of which it is made is for the most part utterly worthless. The road becomes practically impassable in wet weather and well nigh intolerable from dust in dry weather. It must be surfaced with rock or gravel. The work is urgently needed and should be done during the next season. ... This road [new road on right of Grand Canyon] is to connect with the bridge and give access to the right bank of Grand Canyon for about 3 miles below bridge. The present road is one of the hardest to maintain in the park. It has steep grades, is very narrow and is held up by loose retaining walls which are constantly caving in. The material is also very bad and cuts all to pieces in wet weather. It is proposed to bridge Cascade Creek farther upstream and carry the road to the hotel at a higher level. This work will greatly relieve the task of maintenance in this vicinity.[14]

During 1903 and 1904, Chittenden completed several major projects in the park, including the Mount Washburn road and the Melan arch bridge over the Yellowstone River, above the Falls. During the summer of 1903, two crews constructed approximately five miles of well-graded road, a portion of the road was near the Canyon Hotel, and the other near Tower Falls. The work near Tower Falls, which extended into the winter, was of "a very heavy character" as part of the road lay under an overhanging cliff. Chittenden described this segment as a "road of great scenic beauty."[15]

The construction season began late due to remaining snow and soaked ground, leaving few places for desirable camps. By the end of the 1904 season, however, a passable wagon road on the canyon side was opened to within a mile beyond Dunraven Pass and 2½ miles from the summit of Mount Washburn, but Chittenden urgently requested more money for the final completion of the road. He stated in his report for 1904, "This will be by far the finest road for scenery in the park, [but] as it rests on the precipitous sides of the mountain it is important to expend considerably more money to increase its width and erect guard walls at dangerous places." Captain Chittenden feared that the stage companies would not use the single-width road until it was completed. Chittenden found this particular project to be very difficult, due to the lack of desirable camping places, the high altitude, and the great proportion of work through rock.[16]

Yellowstone River Bridge, later known as Chittenden Bridge, was a steel and concrete structure completed in 1903 with great difficulty. Chittenden felt that such a prominent location in the park merited a bridge of artistic design. For many years the idea of a bridge in this location had been contemplated, but lack of funds precluded its construction. Chittenden spent considerable time on site selection. Not wanting to introduce an artificial structure at the most desirable and obvious site, the brink of the Upper Falls where the gap narrows to 50 feet, Chittenden chose a 120-foot span between two jutting rocks, about one-half mile above the Upper Falls at the rapids. Despite the volcanic rhyolite rock being of inferior quality for construction, Chittenden stated "... still from the fact that it has resisted for an indefinite

geological period the action of the river, it must have considerable stability."[17]

Chittenden had many obstacles to overcome, including dangerous rapids below the proposed location of the bridge. One of the most difficult phases of construction involved the framework. All of the rough material was cut locally, but the finer lumber came from the Pacific Northwest. Using a small dynamo, which was borrowed from the hotel company, connected to the rock-crusher engine and a temporary plant to provide artificial light, the crews were able to complete the concrete work by working around the clock.

Because of its prominent location in the park--and therefore in the public eye--and its unique construction difficulties, the holders of the Melan arch patent relinquished all royalty payments. Some of the material for this bridge as well as material for the others built that year came from the American Bridge Company.[18] After considerable controversy, the bridge was removed in 1962.

Before transferring to Mount Rainier National Park at the end of 1905, Major Chittenden summarized the state of the road system in Yellowstone, and made sound recommendations for future work. For this section of Grand Loop Road, Chittenden recommended:

> Lake Junction to Canyon Junction--Concrete culverts should replace the bridge over Sulphur Creek and the one over a stream to the south of Otter Creek. Eighteen-inch pipe culverts should replace two short bridges on the sidehill grade above the second milepost from the Grand Canyon. The Alum and Otter creek bridges should be rebuilt with shorter spans.
>
> Canyon Junction to Tower Junction--earthen embankments and pipe culverts should replace most of the temporary bridges on this route. In some cases, wooden cribs should support the lower side of the embankments.

Chittenden believed that these timber cribs when filled with rocks would last for twenty or thirty years. The Major suggested a possible change to the road location from about 1¼ miles south of Dunraven Pass to the top of the ridge, where the climb from the hotel at Canyon ends. The original intent was to build on a near level line, however, the surveyor who was told to run a constant grade between the two points, became leery after seeing that a swampy area lay in his path. Without permission he ran the line above the swamp resulting in a rise and fall of 70 feet on the line. Chittenden did not feel that the difference was that great but wrote, "... nevertheless, the location is not what was intended and not what it ought to be."[19] Other recommendations for this section called for:

> The little hill about 5¼ miles below the Lake Hotel and another hill a little farther down, where a branch of the Yellowstone flows around an island very close to the road and forms a fine trout pool should each be cut down about 10 feet. The considerable hill in road below the sixth milepost should be cut down to the level of the bench on which the road lies on either side of the hill. A strong timber crib should be built in the water's edge to support the road. ... The side road from the steel-concrete bridge to Artist Point should be given extra width at the lower end, in order that coaches after unloading at the Point may return far enough to be out of each other's way while waiting for the passengers. All of the down

> timber in the narrow and picturesque valley near the Point gathered up and burned.[20]

In 1907 a survey for a new lower level road to connect Canyon and Tower Falls was undertaken, since the existing road was not passable until mid-summer. The crews replaced railings on the bridge at Canyon Junction, replaced the bridge over Sulphur Creek with an iron culvert 3' in diameter and covered with fill 100' long and 14' deep, replaced another bridge, 20' long, 2½ miles south of Canyon with a culvert and necessary fill, and installed three culverts on the Canyon to Inspiration Point road.[21]

In 1912 the 60-foot Alum Creek Bridge was in very bad condition with a sunken center pier. A pile trestle bridge consisting of pile bents and wooden stringers was recommended as a replacement for the Alum Creek Bridge as well as for the 32-foot Otter Creek Bridge which was also in very poor condition. In 1913 a rock-filled log crib was constructed at the canyon near the Upper Falls to replaced a retaining wall which had collapsed during the spring of 1912.[22]

Prior to the road improvements and construction program being turned over the newly-created National Park Service, Captain John Schultz summarized the condition of the park's road in 1917. The Tower Falls to Lake Junction segment was described as follows:

> Lake to Canyon road should be routed via Sulphur Mountain from Trout Creek. Sulphur Mountain is very interesting and should be shown to the passengers. This road is not more than a mile or so longer than the present road. There is an old road going this way which is in very good condition and could be traveled if one or two culverts are replaced. This takes one farther into Hayden Valley, where elk are very often seen.
>
> Bridge across Alum Creek a foot below the road bed and about four inches above the water level. Road along the Yellowstone at the rapids and upper falls very narrow and dangerous. Heavy guard rail should be placed along there.
>
> Approach to the concrete bridge from the opposite side of Yellowstone River in very bad condition.
>
> Going from Canyon toward Dunraven Pass along the hillside half a mile before reaching the entrance of Dunraven Pass, the road should be graded to slope toward the bank and logs should be imbedded along the outer edge of the entire road from this point for about a mile.
>
> Road over top of Mt. Washburn should be cleared of rocks small and large. It is very difficult for a large car to go up there at the present time and extremely hard on tires, as the road is practically covered for miles at a time with sharp stones which have blown onto it.
>
> The last three miles before reaching Tower Falls the road is very rough and narrow and worn. Two or three severe chuck holes.[23]

The next major project for this road was a widening project over Dunraven Pass and at the Grand Canyon of the Yellowstone and the construction of stone parapets between the Upper Falls and Canyon Bridge in 1921.[24]

HISTORY OF GRAND LOOP ROAD: TOWER JUNCTION TO CANYON JUNCTION

In the fall of 1926, E.E. Snyder of the Bureau of Public Roads made a reconnaissance survey for road improvements and construction of the Tower Junction to Canyon Junction section of the road, followed by a location survey, in the fall of 1929, by A.O. Stinson of the Bureau of Public Roads. The location survey revealed that the plan to use as much of the existing road between station 230 and 413 was not feasible. The National Park Service wanted to use the alignment of the old road for its scenic value, as well as to maintain the Mt. Washburn connection. However, park officials agreed with the BPR that few scenic views would be sacrificed by using a more direct and economical route at a lower elevation. Thus, another survey was completed in May 1930. In August of that year, Morrison-Knudsen Company of Boise, Idaho, received the contract and began work.

The contractor selected three camp sites, Camp "A", which accommodated one hundred men, on the left of station 105, Camp "B", which accommodated forty men, on the right of station 450, and Camp "C", which accommodated sixty men, on the left of station 740. The road camp buildings were constructed of rough pine, with tar paper roofs and walls.

This construction project extended from a point one-half mile south of Tower Falls to a point 1¼ miles north of the Grand Canyon rim. The grades from station 0.00 to station 230 ranged from 2 to 7 percent where the road goes over Dunraven Pass, then follows a near level grade along the flank of Mount Washburn, then goes from 4 to 6 percent grades, crossing over the ridge to Antelope Creek basin, terminating at Antelope Creek at the end of the project, station 839+75. Prior to this improvement, most of the traffic that entered the Park from the south and east entrances turned off at Canyon Junction to avoid the excessive grades and sharp curves on the narrow road. In 1930, the cutoff from Canyon Junction to Norris Junction was the major freight route from Mammoth Hot Springs.

The contract called for the construction of an earth graded 18-foot Standard Type 100 road and the installation of 4x4, 5x5, 6x6, and 8x8 concrete box culverts, 24-inch, 30-inch, and 36-inch corrugated galvanized metal pipe culverts, all of which were to have rustic cement rubble masonry headwalls. The contract also specified the construction of cement rubble masonry and wooden guardrails.

One hundred twenty-five men began clearing and excavating for the installation of culverts so sufficient time was available for the heavy equipment usage on the excavation portion. A 1-yard Northwest gas shovel, two 7-yard LaTourneau Hydraulic scrapers, a scarifier and three 60 Caterpillar tractors began work on September 3. A 60 Caterpillar and cables lowered materials for the 6x6 box culvert at station 194+50 down the mountainside. Before closing down for the winter on November 14, the Caterpillars and scrapers had to clear a road through the snow for the men to leave in their trucks and cars. During the winter, a watchman was left at Camp "A" and one at Camp "C".

Work resumed on May 19, 1931. The snow was still 3' to 5' deep between stations 230 and 538, but the contractor was able to open ditches and get the equipment prepared. Between stations 833 and 836, the crews built a hand-laid rock embankment on a 1¼ slope which merged into the newly built cement rubble masonry retaining walls of a ¼:1 slope in such a manner that "it made an exceptionally neat appearing job for which there were many compliments."[25]

Six box culverts were installed on the segment, but no major structures were part of the project. The sand and gravel for the box culverts came from a pit along the Yellowstone River

about twelve miles from the project. The surfacing material for the section between stations 704 and 839 was obtained from a pit on the left of station 725. Other surfacing material came from the cut area between stations 109 and 112.

The grading project was completed ahead of schedule on September 15, 1931, despite sixty-five of the men being "drafted" by the National Park Service to fight the Heart Lake fire for a month during July and August 1931.[26]

By the fall of 1933, the road was surfaced and the Tower Creek Bridge had been completed. Between the time of the grading and the final surfacing, this segment had suffered a number of landslides, and many of the fill areas had settled significantly. It also had become apparent that much of the segment needed additional drainage. The engineers realized that in Yellowstone, "the necessity for stage construction and the use of an oil processed crushed rock surface for a considerable period of time before the placing of a permanent surface."[27]

In early October, a few days after the surfacing had been completed on the Tower Falls to Canyon Junction segment, a massive slide occurred on the vertical face of Overhanging Cliff near Tower Junction. Due to the instability of the formation and the risk to property and life, cleanup and restoration was delayed until the next season. In the meantime, plans were made to remove a section of the Overhanging Cliff. S.J. Groves & Sons Company of Minneapolis, Minnesota received the contract for the low bid of $11,435.00. Following removal of the debris, the masonry guardrails and hand-laid rock embankment had to be reconstructed.[28] In 1935 more columnar basalt dropped into the ditch under Overhanging Cliff. The Bureau of Public Roads planned for one of their contractors to use the stone; however, the National Park Service wanted it left to protect the underlying gravel, hoping it would prevent further erosion and slides. Instead, the Park Service allowed the contractor to use the loose talus slides just south of the Overhanging Cliff for use as surfacing aggregate.[29]

Also during 1935, time was spent trying to obliterate and improve old roads, including one between the Chittenden Bridge and Canyon Lodge and one north of Tower Falls and the southside of the first gulch east of Camp Roosevelt.[30]

The next major project on this stretch--planned prior to the beginning of World War II, but not actually completed until 1949--was a grading and surfacing project in the vicinity of the connecting road leading to the rim of the Grand Canyon of the Yellowstone and the connecting road into Canyon Hotel and parking areas. Shortly thereafter, minor slides and one major slide, involving about 4,000 cubic yards, covered the new road between 13 and 18. The investigation into the cause of the major slide revealed:

> numerous indications of previous land movements in the area immediately above and to the left of centerline of the new highway between stations 12 and 60. The main cause of these land movements appeared to be the extremely 'greasy' character of the soil, aggravated by water seeping from a series of ancient pits or 'Buffalo Wallows' above the new highway. It was at one these pits, approximately 175 feet left of the centerline of the new highway, that the major slide apparently originated. Test holes were drilled on a parallel line, approximately 200 ft. left of centerline, and entrapped water was encountered at a depth varying from 5½ to 6 feet below the surface of the natural ground. This trapped water apparently seeped through a stratum of soft material overlying a stratum of hard clay. Corrected measures consisted of excavating a 400-foot-long trench to the depth of the hard material, installing 6-inch vitrified clay pipe and backfilling with previous sand backfill

> to a depth approximately 6 inches below natural ground surface. This was in turn covered with heavy rock to prevent surface erosion. The excavated material was shaped into a neatly rounded berm below the trench. This construction served the double purpose of removing the trapped water and also of conducting surface water away from cut slopes and roadway and depositing it in a natural drainage channel left of station 19. Excavated material from the slide was spread uniformly over the fill slopes between stations 6+50 and 12+50 of the Cascade Creek fill.[31]

At the completion, a standard 28-foot shoulder-to-shoulder grading was followed with 6" of crushed stone base course treated with MC-1 asphaltic prime. Many minor culverts were installed and the timber guardrail was replaced.[32]

In 1957 new guardrail was installed on the Tower Junction to Canyon Junction section and in 1960, the section was resurfaced and repairs were made to (1959) earthquake-damaged sections. More improvements were carried out in 1962, and in 1966 the Calcite Springs overlook and parking area was reconstructed. In 1985 4,787 linear feet of wooden guardrail was installed between Dunraven Pass and Tower Junction and more repair to the rock wall along the roadside at Calcite Springs was done.[33]

HISTORY OF GRAND LOOP ROAD: CANYON JUNCTION TO LAKE JUNCTION

Between 1931 and 1932, a Location Survey Report was prepared on the Lake Junction and north to Canyon Junction. The report found the Lake Junction to be

> favorably situated with regard to traffic in either direction on the Grand Loop, but unfavorably located with respect to the development at Lake Lodge and Lake Hotel, ... tourists entering the Park via the East Entrance, may pass north of Lake Junction without being aware of the accommodations at these places."[34]

The report described the road from Lake Junction northwards to Canyon Junction average 20' in width and is partially surfaced and all treated with an oil dust palliative. The alignment and grade is fair throughout a large part of the distance, except for occasional dangerously sharp curves and steep grades which appear without warning other than road signs. The most dangerous part of the road is the so-called Trout Creek Hill descending Elk Antler Creek, a small creek seemingly in the Trout Creek valley. This hill combines a sudden excessive drop in grade, when driving northward on the road, with two sharp reverse curves on a steep slope just above the Yellowstone River.[35]

The report described the recently constructed low-type load road up Otter Creek to the newly-built Bear Feeding Grounds, however the report supported the reconstruction of the road to a higher standard. It also stated that the branch road over the Chittenden Bridge to Canyon Lodge on the east bank of the Yellowstone River was being improved at the time. The engineers found the beautiful, although narrow, Chittenden Bridge to be adequate for the present; however, signs of deterioration were noted.[36] Inspiration Point Road from Canyon Hotel Junction had been improved to a higher standard and was deemed adequate for a number of years. Some of the improvements had included widening.[37]

Another Location Survey Report for possible relocation of portions of the Canyon Junction to Lake Junction section was completed in 1937. The report recognized that the

construction of an 800-foot bridge over Cascade Creek would boost the expense of the project. In order to conform with the improved portions of the Grand Loop Road adjacent to this section, the report called for the section to be graded to a 28-foot shoulder-to-shoulder width, with an ultimate surfaced width of 20'. Due to the poor subgrade materials along the entire route, compacted subgrade reinforcement for a depth of 6" would be necessary. The engineers suggested that this material could come from a quarry on Dunraven Pass.[38]

By 1939 no progress had been made on this section. The Bureau of Mines was consulted in regard to possible gas hazards on proposed bridge foundation sites in the Park. The Cascade Creek Bridge was one of the questionable proposed new bridges. The Bureau investigated the effect of sulphur compounds on various materials and concluded, "... it would not be sound engineering to set concrete piers or steel structures in or on the rhyolite formation investigated by them in the acid or sulphate areas of Yellowstone Park. Evidence points to the ultimate failure of concrete foundations in such locations due to one or all of several causes--subsidence, slides, and chemical action."[39]

All major work in the park was suspended at the outbreak of World War II, and with the increased construction costs and several other unanticipated factors, the accepted designs did not consider some essentials. Drainage structures in necessary areas were eliminated, the rolled earth gutter section across the embankment at Cascade Creek was not adequate to prevent erosion, and many of the surfaced areas were not satisfactory.[40] More of the surfacing for the Grand Loop and the Canyon parking areas was done in 1952, with additional surfacing work being done in 1962. Also in 1962, 3,058 linear feet of guardrail was installed and work on done at Otter Creek. In 1985, 110 linear feet of new roadside concrete gravity wall with stone face veneer and masonry parapets, 35' of 6-inch asphalt curb, and 260' of 2-inch asphalt walk was put in at the Sulphur Caldron.[41]

In the 1986 Parkwide Road Engineering Study, the Tower Junction to Lake Junction road was divided into several segments for evaluation and description. The first segment begins at Lake Junction at milepost 88.72 and ends at milepost 93.56, near Mud Volcano. This section of road has a surface width of 23'. A bituminous plant mix was applied in 1983. The surface condition is good. The base and subgrade condition is fair and the drainage condition is good. There are no shoulders. The horizontal and vertical alignment is good. The roadside condition along this section is poor; narrow and sharp clearing lines obstruct the view from the road and detract from the visual quality in section of exceptional scenic beauty. In 1985, the average daily traffic was 5,600 vehicles with an anticipated volume of 6,850 vehicles by 2005. There are no major structures on this segment.

The next segment begins at milepost 93.56 and ends in the northerly end of Hayden Valley, at milepost 99.65. This section of road has a shoulder-to-shoulder width of 25' and is surfaced with a bituminous plant mix. The condition of the surface is fair with extensive broken down pavement edges. The surface width varies from 22' to 25'. The base and subgrade condition is good and the drainage condition is good. The width of the shoulders vary from 0' to 2' and their condition is poor. The horizontal and vertical alignment is good. The general condition of the roadside is good and the open roadside does provide the visitors with ideal visibility of the resources. In 1985, the average daily traffic was 5,600 vehicles with an anticipated volume of 6,850 vehicles by 2005. There are no major structures on this segment.

From milepost 99.65 to 103.71 near Canyon Junction, the roadway width from shoulder to shoulder ranges from 23' to 25' and the shoulder width varies from 0' to 2'. The road is covered with a bituminous plant mix and the surface is in fair to good condition. The base and the subgrade is in fair to good condition and the drainage is in good condition. The horizontal and vertical alignment is in good condition. The roadside condition is fair. The Otter Creek Bridge is the only major structure on this section. In 1985 the average daily traffic was 5,600 vehicles with

an anticipated volume of 6,850 vehicles in 2005.

The next segment begins near Canyon Junction at milepost 103.71 and ends at milepost 108.54 at the summit of Dunraven Pass. The road width from shoulder to shoulder on this section varies from 22' to 24'. The shoulder width ranges from 0' to 2'. The surface of the roadway is a bituminous plant mix and it is in poor condition. The drainage is in good condition and the base and subgrade is in fair condition. The horizontal alignment is in fair condition and the vertical alignment is in good condition. The roadside condition is fair, but encroaching vegetation obstructs the view in some locations. In 1985, the average daily traffic was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. There are no major structures on this section.

At milestone 108.54 to 113.44 at the junction of the Chittenden Bridge Road (Route 238), the roadway width from shoulder to shoulder is 22' to 24'. The pavement or surface width is from 20' to 22'. The surface is a bituminous plant mix and the condition is poor. The base/subgrade condition is fair and the condition of the drainage is good. The shoulder width ranges from 0 to 2 feet and the condition of the shoulders is poor. The horizontal and vertical alignment is fair and the roadside condition i s fair. In 1985, the average daily traffic was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. There are no major structures on this section.

The next segment is from milepost 113.44 to Tower Falls at milepost 119.56. The roadway width from shoulder to shoulder ranges from 22' to 26' and the pavement or surface width varies from 20' to 22'. The roadway is surfaced with a bituminous plant mix and the condition is poor. The condition of the base/subbase is fair to poor and the drainage condition is fair. The shoulder width is from 0' to 2' and the condition of the shoulders is poor. The horizontal alignment is poor and the vertical alignment is fair. The condition of the roadsides is good. There are no major structures on this section. The average daily traffic was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005.

The last segment begins at Tower Falls at milepost 119.56 and ends at the junction of the Grand Loop Road and the Northeast Entrance Road (Route 12). The roadway width from shoulder to shoulder is 22' to 24' and the pavement or surfaced width is from 20' to 22'. The road is surfaced with a bituminous plant mix and the condition is fair to poor. The subgrade and base condition is fair and the drainage condition is good. The shoulders width range from 0' to 1' and the condition of the shoulders is poor. The horizontal alignment is poor and the vertical alignment is good. The roadside condition is good. The average daily traffic in 1985 was 3,850 vehicles with an anticipated volume of 4,700 vehicles in 2005. The only major structure on this section is the Tower Creek Bridge.

HISTORY OF TOWER CREEK BRIDGE

The first investigations for construction of Tower Creek Bridge were made by the Bureau of Public Roads in 1926. More surveys which settled the exact location of the bridge site were made in 1929 and 1930 by BPR engineers A.O. Stinson and L.A. Hamilton. Because of the highly specialized work of this project, it was deemed necessary to not include any other work in the contract.

On July 28, 1932, McLaughlin Construction Company of Livingston, Montana, received the contract based on a low bid of $19,528.00. Shortly thereafter, the contractor established a camp about 300 feet from the road, opposite station 920 between Tower Junction and Overhanging Cliff. He also set up a screening plant at the sand and gravel pit on the old road, about one-half mile from the Tower Creek Campground. As the crews were stockpiling concrete aggregates, stone cutters were quarrying stone for the arch ring and wall facing. The quarrying and facing of the stone required highly skilled men. In addition to these two operations, the excavation began for the footing of the concrete arch abutments and spandrel walls. These three

operations required a crew of twenty to twenty-four men.

The only significant difficulty was keeping the flow of traffic over the old bridge while constructing the new one. A portion of one of the abutments had to be removed from the old bridge before the footing for one spandrel wall on the downstream side could be poured. Nevertheless, the work was accomplished without delaying traffic. A change in the aggregate mix had to be made after discovering that the stockpiled aggregate was a different grade than what was being brought in.

By November bad weather conditions forced the crew to abandon the project for the season, but not before the concrete arch ring and wall facing stones were in place. At that time most of the parapet wall construction had been completed and the bridge had been backfilled.

On May 24, 1933, the crew resumed building the hand-laid embankment and the masonry wall on the west end of the bridge, installing the curb stones and backfilling the structure. The bridge was completed on June 20, 1933.[42]

DESCRIPTION

The bridge is a 40-foot reinforced-concrete arch span, with 110-foot spandrel walls, faced with stones. Earth material was used in the backfilling between the walls, over the barrel of the bridge, and on the construction of the approach fills. The roadway width, curb-to-curb, is 30', with a 3-foot sidewalk on either side. Parapet walls 2'-3" rise above the level of the sidewalks.

Tower Creek Bridge's arch springs from an elevation of 6,424 feet and rises 16'-2¾" to the masonry. The arch has two radii. The radius 9'-9" above the spring line is 13'-5", while the radius 9'-9" below the spring line is 22'-6". The masonry facing on the underside of the arch is 2" thick. The arch barrel has concrete 1' thick. In this concrete, deformed bars reinforce the arch barrel. Longitudinal arched bars of ¾-inch diameter are placed near the top and bottom of the concrete arch barrel on 12-inch centers. One-half-inch diameter hoops face longitudinally in the arch barrel and are staggered at 2-foot centers. Transverse bars of ½-inch diameter are placed near the top and bottom of the concrete arch barrel on 2-foot centers. The concrete in the arch barrel and spandrel walls is class "A". "A" refers to the amount of cement in the mix. "A" is the highest strength for a given aggregate because of the greater cement content.[43]

The spandrels of the arch are also reinforced. The longitudinal reinforcement consists of ½"-diameter bars at 2-foot centers. The vertical reinforcement consists of 1 inch diameter bars at 6½-inch centers going down to ½-inch diameter bars at 1-foot centers near the middle of the arch. The inside of the spandrel walls and top of the concrete arch barrel are membrane waterproofed.[44]

The outside of the spandrel walls are faced with stones a maximum of 2'-0" deep to a minimum 1'-6" deep. The facing stones are carried to solid rock at the abutments. The facing rock is secured with U-shape bars embedded in the mortar joints at one bar to each 5 square feet of wall surface. The ring stones outlining the arch barrel are held by two clamps.[45] Backfilling between walls and over the barrel of the bridge was made with earth material.

The abutments are keyed into solid rock except on the south side where a foundation of large boulders wedged with rock and gravel was used after digging an additional 3' to find ledge rock. The wing walls extend about 25' beyond the abutment. They sit on rectangular footings which were poured at the same elevation as the abutment footings except on the upstream section of the north wing wall which was stepped six times on solid rock. The footings have transverse and longitudinal reinforcing as well as bars bent into the toe of the footing from the vertical part of the wing walls. The concrete in the abutments and footings is class "B".[46]

The estimated quantities of materials were as follows:

Concrete Class "A"	325 cu. yds.
Concrete Class "B"	145 cu. yds.
Reinforcing steel	35,000 lbs.
Arch ring facing	65 sq. yds.
Masonry	215 cu. yds.
Structural excavation	725 cu. yds.
Curb stones	228 lin. ft.
Membrane waterproofing	370 sq. yds.

The stones for the arch rings and wall facings were obtained from a rhyolite quarry about 500 feet right of station 28 on the Tower Junction to Mammoth Hot Springs road. The masonry work on this bridge was under the direction of Mr. Camillie, who had constructed the White River Bridge in Mount Rainier National Park. The total cost of the bridge was $22,417.00.[47]

ENDNOTES

1. William A. Jones, "Report Upon the Reconnaissance of Northwestern Wyoming Including Yellowstone National Park Made In the Summer of 1873" (Washington, D.C.: Government Printing Office, 1875), p.58.

2. Philetus W. Norris, "Report Upon the Yellowstone National Park for the Year 1878, to the Secretary of the Interior" (Washington D.C.: Government Printing Office, 1878), pp.983-84.

3. Norris, "Annual Report of the Superintendent of the Yellowstone National Park for the Year 1879."

4. Norris, "Annual Report of the Superintendent of the Yellowstone National Park for the Year 1880," p.38.

5. Norris, "Fifth Report of the Superintendent of the Yellowstone National Park, September, 1881," pp.69-70.

6. Ibid.

7. P.H. Conger, "Annual Report of the Superintendent of the Yellowstone National Park to the Secretary of the Interior for the Year 1882, p.6.

8. "Annual Report of Captain Clinton B. Sears, Army Corps of Engineers, for the Fiscal Year Ending June 30, 1887," appendix to "Report of the Secretary of War Being Part of the Messages and Documents Communicated to the Two Houses of Congress in Four Volumes" (Washington, D.C.: Government Printing Office, 1887), pp.3138-39.

9. "Annual Report of Major Charles J. Allen, Army Corps of Engineers, Officer in Charge, for the Fiscal Year Ending June 30, 1889," appendix to "Report of the Secretary of War Being Part of the Messages and Documents Communicated to the Houses of Congress and the Beginning of the First Session of the Fiftieth Congress in Four Volumes," (Washington, D.C.: Government Printing Office, 1889), pp. 2857-59.

10. George Anderson, "Report of the Superintendent of the Yellowstone National Park to the Secretary of the Interior, 1892" (Washington, D.C.: Government Printing Office, 1892), pp.3-5.

11. Anderson, "Annual Report of the Superintendent of the Yellowstone National Park to the Secretary of the Interior, 1893," p.8.

12. Anderson, "Report of the Acting Superintendent of the Yellowstone National Park to the Secretary of the Interior, 1895," p.8.

13. Anderson, "Report of the Officer in Charge of Construction and Maintenance of Roads, Etc., in the Yellowstone National Park to the Secretary of War, 1896" (Washington, D.C.: Government Printing Office, 1896), p.5.

14. Hiram Chittenden, "Roads In Yellowstone National Park," Senate Document 226, Fifth Congress, First Session. Letter from the Acting Secretary of War Transmitting in Response to Resolution of the Senate of March 12, 1900, Letter From the Chief Engineers, U.S.A., Together With the Copies or Originals of all Reports Relating to the Present Condition and Appropriate Plans for the Development of the System of Roads in the Yellowstone National Park.

15. Chittenden, "Annual Reports Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park and Construction of Military Roads from Fort Washakie to Mouth of Buffalo Fork of Snake River, Wyoming, and Erection of Monument to Sergeant Charles Floyd in the Charge of Hiram A. Chittenden, Captain, Corps of Engineers for 1903" (Washington, D.C.: Government Printing Office, 1903), p.2891.

16. Chittenden, "Annual Report Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park ... Being Appendices FFF and KKK of the Chief of Engineers for 1904" (Washington, D.C.: Government Printing Office, 1904), pp.4173, 4176-77.

17. No author (Hiram Chittenden?), "Technical Report Upon the Improvement of Yellowstone National Park, 1904," p.58.

18. "Technical Report ... 1904," p.58.

19. Chittenden, "Annual Report Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park in the Charge of Hiram A. Chittenden, Captain, Corps of Engineers, Being Appendices GGG and KKK of the Chief of Engineers for 1905" (Washington, D.C.: Government Printing Office, 1905), p.2818.

20. Ibid., p.2818.

21. Ernest Peek, "Annual Report of the Chief of Engineers for 1907" (Washington, D.C.: Government Printing Office, 1907), p.2664.

22. Captain C.H. Knight, Major J.B. Cavanaugh, and Major Jerry J. Morrow, "Report Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park; Report Upon the Road Into Mount Rainier National Park; and Report Upon Crater Lake National Park," Appendices EEE and FFF (Washington, D.C.: Government Printing Office, 1913), p.3269.

23. Captain John Schultz, Letter to Chester Lindsley, 17 October 1917.

24. "Report of the Director of the National Park Service to the Secretary of the Interior for the Fiscal Year Ended June 30, 1921 and the Travel Season 1921" (Washington, D.C.: Government Printing Office, 1921), p.167.

25. "Final Construction Report, 1930-1931, on Canyon Junction-Tower Junction Project, 1-G-1 Grading, Yellowstone National Park, State of Wyoming, January 30, 1932."

26. Ibid.

27. F.A. Kittredge, Chief Engineer, National Park Service, Letter to Director of the National Park Service, 5 September 1933, (File 332.1, Box-Road Construction, 1933, Yellowstone National Park Archives, Yellowstone National Park).

28. H.E. Dalton, "Final Construction Report (1934) on Grand Loop, Slide Removal Section NR 1-G2, Yellowstone National Park, Wyoming, March 4, 1935."

29. C.F. Capes, Letter to Mr. Russell, Bureau of Public Roads, 31 August 1935.

30. Roger Toll, Superintendent of Yellowstone National Park, Letter to C.F. Capes, Bureau of Public Roads, 23 October 1935. Roger Toll, Memorandum to Mr. Emmert, Yellowstone National Park, 3 September 1935.

31. James Smith, "Final Construction Report (1948-49) on Grand Loop National Park Highway Project 1-F3, G4 Grading and Base Surfacing Yellowstone National Park, State of Wyoming, March 2, 1950".

32. Ibid.

33. Real Property Record, Yellowstone National Park, National Park Service, Rocky Mountain Regional Office, Denver, Colorado.

34. A.O. Stinson, "Location Survey Report 1931-32 on Bridge Bay--Inspiration Point Survey including Section F and parts of Sections E and G of Route I, the Grand Loop System, and a part of Section D of Route 5, the East Entrance Highway, Yellowstone National Park, Wyoming, January 20, 1934.

35. Ibid.

36. Ibid.

37. Ibid.

38. Robert Bond, "Preliminary Location Survey Report on Relocation of Portions of Sections 1-F, 1-G Grand Loop Highway, Yellowstone National Park, Wyoming, February 26, 1938."

39. S.H. Ash, Bureau of Mines District Engineer, and W.W. Kessler, "Investigation of Gas Hazards Proposed Bridge Foundation Sites in Yellowstone National Park," 1939 (File, "Canyon Junction Vicinity--Cascade Creek, Part 2, 1 January 1940 to 31 December 1943," Box 40, Yellowstone National Park, National Archives and Records Center, Denver, Colorado).

40. Regional Director, Region Two, National Park Service, Memorandum to Yellowstone National Park Superintendent, 8 June 1950.

41. Real Property Record, Yellowstone National Park, National Park Service, Rocky Mountain Regional Office, Denver, Colorado.

42. H.E. Dalton, "Final Construction Report 1932-1933 on Project 1-G2, Bridge Accounts No. 1475, Yellowstone National Park, Wyoming, 9 April 1934."

43. Bureau of Public Roads, Department of Agriculture, Tower Creek Bridge Plans, October 1931.

44. Ibid.

45. Ibid.

46. Ibid.

47. Ibid. "Monthly Narrative Report, Yellowstone National Park, Bureau of Public Roads, District No. 3, 31 August 1932.